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SID 63-691

PROJECT APOLLO END ITEM SPECIFICATION BOILERPLATE NUMBER 16

(U)

12 December 1963

NAS9-150

Paragraph 4.2, Exhibit I

[redacted]

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

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PROJECT APOLLO
END ITEM SPECIFICATION
BOILERPLATE NUMBER 16

1. SCOPE

1.1 Scope.- This specification defines the requirements for a simulated Apollo spacecraft consisting of a launch escape system (LES), command module (CM), service module (SM), and adapter hereinafter referred to as Boilerplate Number 16.

1.1.1 Specification Organization.- This specification is organized as follows:

Basic section

Appendix A - Drawings

Appendix B - Flight Hardware

1.1.2 Mission.- Boilerplate Number 16 is the vehicle for the micrometeoroid experiment.

1.1.3 Objectives.- Boilerplate Number 16 shall be used for the launch vehicle qualification and micrometeoroid experiment. Other test objectives will be determined by MSFC.

2. APPLICABLE DOCUMENTS

2.1 Applicability.- The following documents of the issue in effect on the date of contract form a part of this specification to the extent specified herein.

2.1.1 Government Documents.-

SPECIFICATIONS

Military

MIL-E-5400	Electronic Equipment, Aircraft, General Specification for

MIL-I-8500	Interchangeability and Replaceability of Component Parts for Aircraft and Missiles, Specification for
MIL-L-6880	Lubricating, Aircraft, General Specification for
MIL-R-27542	Reliability Program Requirements for Systems, Subsystems, and Equipment, Specification for

STANDARDS

MIL-STD-130	Identification Marking of U.S. Military Property

National Aeronautics and Space Administration (NASA)

NPC 200-2	Quality Assurance Provisions for Space Contractors, dated 20 April 1962

2.1.2 Non Government Documents.-

SPECIFICATIONS

North American Aviation, Inc., Space and Information Systems Division (NAA/S&ID)

MA 0116-012	Preparation for Delivery and Transport of Apollo Boilerplates, Specification for
MC 999-0002B	Electromagnetic Interference Control for the Apollo Space System, Specification for

OTHER DOCUMENTS

SID 62-109	General Test Plan, Research and Development for Project Apollo Spacecraft
SID 62-223	Apollo Program Plan
SID 63-313	Apollo Master Spacecraft Specification

DRAWINGS

North American Aviation, Inc., Space and Information Systems Division NAA/S&ID

B14-000024	Finish Specification, Apollo Boilerplate, Complete
B14-000002-231	General Assembly, Boilerplate Number 16
B15-000002-171	General Assembly, LES 12
B16-000002-281	General Assembly, CM 22
B17-000002-191	General Assembly, SM 5
B18-000002-221	General Assembly, Adapter 11
B18-320113	Structure-Insert

2.2 Precedence. - The order of precedence in case of conflict will be as follows:

(a) The contract

(b) This specification

(c) Other documents referenced herein.

3. REQUIREMENTS

3.1 General. - The following paragraphs delineate the requirements for design, fabrication, assembly, and performance for Boilerplate Number 16. Systems and subsystems development plan philosophy is reflected in SID 62-223, Apollo Program Plan.

3.1.1 Weight. - Weight, center of gravity, and moments of inertia data for Boilerplate Number 16 are listed in Table I.

3.1.2 Materials. - Materials shall be compatible with design, weight, and load criteria.

3.1.2.1 Fabrication. - Structural design concepts of Boilerplate Number 16 emphasize employment of proven manufacturing techniques and methods to the greatest possible extent. Maximum use shall be made of developed "off-the-shelf" components fabricated by dependable manufacturers.

3.1.3 Design Criteria. - Design criteria shall be in accordance with rational design principles as specified in Specification SID 63-313.

3.1.3.1 Electromagnetic Interference. - Electromagnetic interference control shall be in accordance with SID Specification MC 999-0002.

3.1.3.2 Environment. - The environmental design criteria for Boilerplate Number 16 shall be as specified in Specification SID 63-313.

3.1.3.3 Checkout Provisions. - Boilerplate Number 16 shall be designed with provisions for system and integrated systems checkout and test capabilities.

3.1.4 Interchangeability. - Interchangeability as defined for the Apollo Program shall be in accordance with Specification MIL-I-8500 and shall apply to all completely finished assemblies, components, and parts which shall be capable of being readily installed, removed, or replaced without alteration, misalignment, or damage to parts being installed or to adjoining parts. No fabrication operations, such as cutting, filing, drilling, reaming, hammering, bending, prying, or forcing, shall be required for installation.

3.1.4.1 Interchangeability of Electronic Equipment. - Interchangeability of electronic equipment shall be in accordance with Specification MIL-E-5400, where applicable. Interchangeability of electronic equipment for the Apollo Program shall require that mechanical and electrical interchangeability shall exist between like assemblies, subassemblies, and replaceable parts be easily effected without physical or electrical modification to any part of the equipment, including; cabling, wiring, and mounting and without resorting to selection; however, adjustment, trimming, or calibration may be made.

3.1.5 Replaceability. - Replaceability, as defined for the Apollo Program, shall be in accordance with Specification MIL-I-8500 and shall apply to parts which may require additional work or operations during installation. This may include such additional operations as drilling, reaming, cutting, filing, trimming, shimming, or other means, normally associated with installing the original assembly into the end item. Replaceable parts shall be designed to permit replacement under field maintenance conditions.

3.1.6 Finish. - Finish requirements shall be as specified in SID Drawing B14-000024.

3.1.7 Identification and Marking. - Specification MIL-STD-130 shall be considered as a reference guide in identification marking of equipment, assemblies, and parts.

3.1.8 Identification and Traceability. - Identification and traceability shall be in accordance with the requirements of Specification MA-0201-0208 for those parts jointly agreed upon by the NASA and NAA/S&ID.

3.1.9 Lubrication. - Lubrication of components, where required, shall be in accordance with the requirements of Specification MIL-L-6880. No petroleum-base lubricants shall be used. Lubricants shall be of the silicone base, fluorolube, oxylube 702, and dry film type. Lubrication shall not cause any toxic or flammable substances to occur in the CM or in the environmental control system.

3.1.10 Reliability. - An integrated reliability program, generally in accordance with Specification MIL-R-27542, shall be conducted throughout the design, development, and fabrication of Boilerplate Number 16.

3.2 Configuration. - The configuration of Boilerplate Number 16 is shown in Figure 1. For detailed configuration information, refer to SID Drawing B14-00002-231. The S-1 Launch Vehicle is shown for information purposes only.

3.2.1 Launch Escape System. - The LES shall consist of the following major components. Refer to NAA/S&ID Drawing B15-000002-171 for detailed configuration.

(a) Nose cone

(b) Pitch control motor (inert)

(c) Tower jettison motor

(d) Launch escape motor (inert)

(e) Structural skirt

(f) LES tower

(g) LES tower separation sequencer.

3.2.1.1 Nose Cone. - The LES nose cone shall provide the capability for accommodating 1,500 pounds of lead ballast and a pitch control motor mounted normal to the X axis.

3.2.1.2 Pitch Control Motor. - The pitch control motor shall be an inert solid propellant motor and shall be mounted aft of the nose cone. It shall simulate the weight and c.g. of an active pitch control motor.

3.2.1.3 Tower Jettison Motor. - The tower jettison motor shall be a solid propellant motor 55.6 inches in length and 26 inches in diameter. The motor shall have two fixed thrust nozzles canted 30 degrees from the mean motor centerline. The resultant thrust axis shall be located 2.5 degrees plus or minus 30 minutes from the mean motor centerline of the pitch plane. The jettison motor shall weigh approximately 534 pounds, which includes the interstage structure, shall develop 33,000 pounds of thrust and shall fire for 1.2 seconds. The rocket motor shall be ignited by a pyrogen type igniter which shall utilize two hotwire initiators.

3.2.1.4 Launch Escape Motor. - The launch escape motor shall be an inert solid propellant motor with an approximate length of 183 inches and 26 inches in diameter with a gross weight of approximately 4,826 pounds. Approximately 3,200 pounds of solid propellant fuel will be simulated to acquire the weight and c.g. of an active launch escape motor.

3.2.1.5 Structural Skirt. - A structural skirt assembly shall be utilized to mount the launch escape motor to the tower. The skirt shall be constructed of a forged ring with longerons, welded to a shear skin, that shall transfer uniform load from the launch escape motor to four points at the launch escape tower legs. The structural skirt shall be bolted to the LES tower.

3.2.1.6 Launch Escape Tower. - The launch escape tower shall be a four-legged welded tubular alloy, truncated rectangular cross-sectioned pyramid, approximately 120 inches in length with a base 46 inches by 50 inches. The tower shall form the intermediate structure between the CM and the launch escape motor. At the top of the tower, immediately below the structural skirt separation plane, an aerodynamic flap shall be installed normal to the minus Z axis. At the bottom of the tower, quick-release mechanisms shall be incorporated to attach the tower to the CM inner structure and to the forward heat shield.

3.2.1.7 LES Tower Separation Sequencer. - The two LES tower separation sequencers shall control, upon receipt of tower separation signal, (1) launch escape tower separation and (2) ignition of the LES jettison motor. The separation signals shall be transmitted through redundant busses, A and B.

3.2.1.8 Electrical System. - The LES electrical system shall consist of the following major components:

(a) Mission sequencer (located in CM)

(b) Hotwire initiators

(c) Hotwire firing units

(d) Associated pyrotechnic batteries, wiring, and attachments.

3.2.1.8.1 Mission Sequencer. - The mission sequencer shall automatically control LES tower separation sequencer and CM-SM separation. Other functions of the mission sequencer are undetermined at this date.

3.2.1.8.2 Hotwire Initiators. - The hotwire initiators contain two electrical high resistant wires threaded into pyrotechnic cartridges which fire the igniter of the rocket motor. The initiators shall be redundant for increased reliability.

3.2.1.8.3 Hotwire Firing Units. - The hotwire firing units shall be pyrotechnic cartridges which shall be detonated by current passing through the high resistant electrical hotwire initiators. The pyrotechnic cartridges shall then fire the rocket motor igniters.

3.2.1.8.4 Pyrotechnic Batteries. - The pyrotechnic batteries for the LES shall be housed in the CM. Electrical wiring shall provide the means by which current will be carried from the batteries to the pyrotechnic firing units.

3.2.1.9 Umbilical System. - The umbilical system shall contain electrical wiring between the CM and LES. The umbilical shall be detached by force on the lanyard type disconnect when the LES jettison motor causes CM-LES separation.

3.2.1.10 Pyrotechnic System. - The pyrotechnic system shall consist of the following:

(a) Pyrotechnic batteries

(b) Hotwire initiators

(c) Disconnect assemblies.

3.2.1.11 LES Tower Separation System. - The LES tower separation system shall consist of explosive bolts, used for LES tower - CM attachment, and flexible linear shaped explosive charges placed at the four attachments that secure the tower to the CM. Redundant hotwire initiators shall be used to detonate the explosive bolts and flexible linear shaped explosive charges. The hotwire initiators shall be actuated by 28 volt dc signals which shall be received from the redundant LES tower separation sequencer. To accomplish LES tower jettison, the tower separation sequencer will simultaneously apply detonation signals to the explosive bolt initiators and the tower jettison motor firing units. The LES assembly will be released and propelled clear of the boilerplate trajectory.

3.2.2 Command Module. - The CM shall consist of the following:

(a) CM structure

(b) Mission sequencer

(c) Electrical power system

(d) The R and D communications equipment

(e) The R and D instrumentation equipment

(f) Environmental Control System (ECS).

3.2.2.1 Command Module Structure. - The CM shall be of conical design, approximately 141 inches high and 154 inches in diameter at the base with a net weight of approximately 9000 pounds. The structure shall be fabricated from aluminum with a skin thickness of approximately 0.190 inches. Attach fittings shall be provided at the forward bulkhead to engage the launch escape tower. The configuration of the CM shall be in accordance with SID Drawing B16-000002-281 and shall be similar to the ultimate spacecraft CM. All equipment in the CM shall be placed as near as possible to the position to be occupied in the ultimate spacecraft CM. The CM structure shall include the following:

(a) Cabin housing
  (1) Forward Bulkhead

  (2) Forward crew compartment

  (3) Aft crew compartment

(b) Heat shield structure

(c) Separation system.

3.2.2.1.1 Cabin Housing. - The CM shell shall be constructed of aluminum alloy welded into two subassemblies, (1) the forward crew compartment and (2) the aft crew compartment. The subassemblies shall be bolted together and the aft skirt frames and skin shall be attached by mechanical fasteners.

3.2.2.1.2 Forward Bulkhead and Egress Tube. - The forward bulkhead structure shall consist of a double skin with riveted stiffeners. The closeout skin shall be attached to stiffeners by blind fasteners. The egress tube shall consist of a welded sheet tube of aluminum welded to the forward bulkhead. A cover plate shall be bolted to the top of the egress tube.

3.2.2.1.3 Forward Crew Compartment. - The forward crew compartment shall consist of multi-stiffeners welded to the outer skin. The stiffeners shall consist of four main longerons attached to the launch escape tower fittings in the forward bulkhead and terminate in the mid-ring splice joint at the aft end of the forward section of the crew compartment. Several secondary longerons shall be utilized for load transfer from the forward bulkhead to the mid-ring. The remaining stiffeners shall assist the skin in resisting airloads.

3.2.2.1.4 Aft Crew Compartment. - The aft section of the crew compartment shall consist of a sidewall with stiffeners, corresponding to those of the forward section of the crew compartment, from the mating aft section of the crew compartment mid-ring to the machined ring forging at the junction of the sidewall and the floor.

3.2.2.1.5 Apex Forward Compartment Heat Shield Cover. - The apex forward compartment heat shield cover structure shall form the forward section of the CM structure and shall consist of an aluminum alloy skin and stiffeners utilizing riveted and bolted construction. A lightweight inner skin shall be used to insure a smooth surface such that the forward compartment cover shall not interfere with the parachute bags or equipment upon ejection. The nose cone will be aluminum.

3.2.2.1.5.1 CM Insulation. - The CM exterior shall be provided with suitable cork insulation to protect the module from aerodynamic heating during the launch phase.

3.2.2.1.6 Access Hatch. - The main hatch shall provide access to the CM interior. The hatch shall be constructed of reinforced aluminum plate and shall be bolted into place. It shall be located in the CM sidewall over the head of the center couch position.

3.2.2.1.6.1 Access Doors. - Access doors shall be provided in the skirt structure for servicing the heat shield attach struts. Four openings shall be provided in the forward crew compartment structure, approximately 90 degrees apart, for telemetry antennas.

3.2.2.1.7 Mission Sequencer. - The mission sequencer shall automatically control LES-CM and CM-SM separation. Other possible functions of the mission sequencer will be at the discretion of the MSFC.

3.2.2.1.8 Electrical Power System (EPS). - The CM EPS shall supply and distribute electrical power and shall consist of the following major components:

(a) Main power batteries

(b) Pyro-batteries

(c) Electrical distribution system

(1) CM-LES umbilical

(2) CM-SM umbilical

3.2.2.1.9 R and D Communications Equipment. - NAA/S&ID has no requirement for R and D communciations equipment in Boilerplate Number 16.

3.2.2.1.10 R and D Instrumentation Equipment. - NAA/S&ID has no requirement for R and D instrumentation equipment in Boilerplate Number 16.

3.2.2.1.11 Environmental Control System. - NAA/S&ID has no requirement for an ECS in Boilerplate Number 16.

3.2.2.1.12 CM-SM Attach System. - The CM-SM attach system shall utilize positive tension ties through the three SM compression pads. The three preloaded tension straps shall be secured to the CM inner structure and the SM at the upper beam.

3.2.2.1.13 CM-SM Separation. - Capability for CM-SM separation is not provided for Boilerplate Number 16.

3.2.3 Service Module. - The SM shall be a cylinder approximately 124 inches in length and 154 inches in diameter. The structure shall be aluminum semi-monocoque construction consisting of skin, longerons, and frames.

3.2.3.1 SM Reaction Control System (RCS). - The SM RCS engines shall be installed at station 325. The RCS quad packages shall be dummy motors simulating the size, weight, shape, location, and aerodynamic characteristics of the ultimate spacecraft RCS.

3.2.3.2 SM Insert. - The SM insert shall be located between the adapter and SM. The insert shall be an aluminum cylinder of semi-monocoque construction approximately 52 inches in length and 154 inches diameter.

3.2.3.3 Adapter. - The adapter shall be an aluminum cylinder of semi-monocoque construction approximately 92 inches in length and 154 inches diameter. It shall be located between the SM insert and the S-IV stage of the S-1 Launch Vehicle.

3.2.3.4 SM Purging. - Provisions shall be made in the SM to attach GSE GN_2 purging lines.

3.2.3.5 SM Protective Bulkhead. - A protective bulkhead shall be attached to the lower ring in the SM adapter. This bulkhead shall be an air conditioning barrier to isolate the S-IV cooling system from the adapter cavity.

3.2.4 Launch Vehicle. - The launch vehicle for Boilerplate Number 16 will be the Saturn I Block II configuration.

3.3 Performance. - The performance of Boilerplate Number 16 will be outlined by the MSFC.

3.3.1 Trajectory Parameters. - To be determined by the MSFC.

3.3.2 Flight Plan. - To be determined by the MSFC.

4. QUALITY ASSURANCE

4.1 General Quality Assurance Provisions. - The principal contractor (S&ID) shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the principal contractor may utilize his own or any other inspection facilities and services acceptable to the NASA. Inspection records of the examinations and tests shall be kept complete and available to the NASA as specified in the contract.

4.2 Principal Contractor's Quality Assurance Program. - The principal contractor shall establish a quality assurance program in accordance with the requirements of paragraph 6 of Exhibit I of the contract. Inspections and tests to determine conformance of Boilerplate Number 16 to contract and specification requirements shall be conducted prior to submission of the article to the NASA for acceptance.

4.2.1 Reliability Data. - The principal contractor shall act as a test historian and accumulate applicable data on spacecraft tests, plans, and performance from preparation to delivery. The data shall be used in qualitative and quantitive assessments of reliability and performance of each system, and of the ultimate spacecraft. This data, together with other appropriate data, such as acceptance data, shall be integrated with that accumulated from prior tests to form assessments. Thus, a probability of success may be provided for any given phase. The reliability data may also be compared with program objectives in order to assure that these have been attained.

4.3 Examination. - Each assembly and all major components submitted for acceptance shall be subjected to a visual examination to determine conformance to materials, design, construction, dimensions, color and finish, product marking, and workmanship.

4.3.1 Components. - The principal contractor shall ascertain that, prior to assembly, all parts, components, assemblies, and systems procured under separate specifications or drawings have been inspected, tested, and accepted in accordance with their respective specifications or drawings.

4.4 Tests. - Each assembly, major component, and system submitted for acceptance shall be subject to performance tests as specified in SID 62-109.

5. PREPARATION FOR DELIVERY

5.1 Preservation, Packaging, and Packing. - Preservation, packaging, and packing shall be in accordance with the principal contractor's procedures specified in SID Process Specification MA 0116-012.

6. NOTES

6.1 Delivery of Modules. - The SM , Adapter and Insert will be delivered separately to the MSFC for instrumentation. The LES and CM will be delivered at a later date.

TABLE I

ESTIMATED WEIGHTS AND CENTER OF GRAVITY

ITEM	WEIGHT*	CENTER OF GRAVITY X_a	Y	Z
Launch Escape System	6,290	1293.8	0.0	0.0
Command Module	4,660	1036.6	0.3	1.2
Service Module	3,930	949.7	0.1	0.5
Insert	1,130	840.1	0.0	0.0
Adapter	2,090	763.2	0.0	0.0
Total	18,100	1063.2	0.1	0.2

NOTE: *No ballast included.

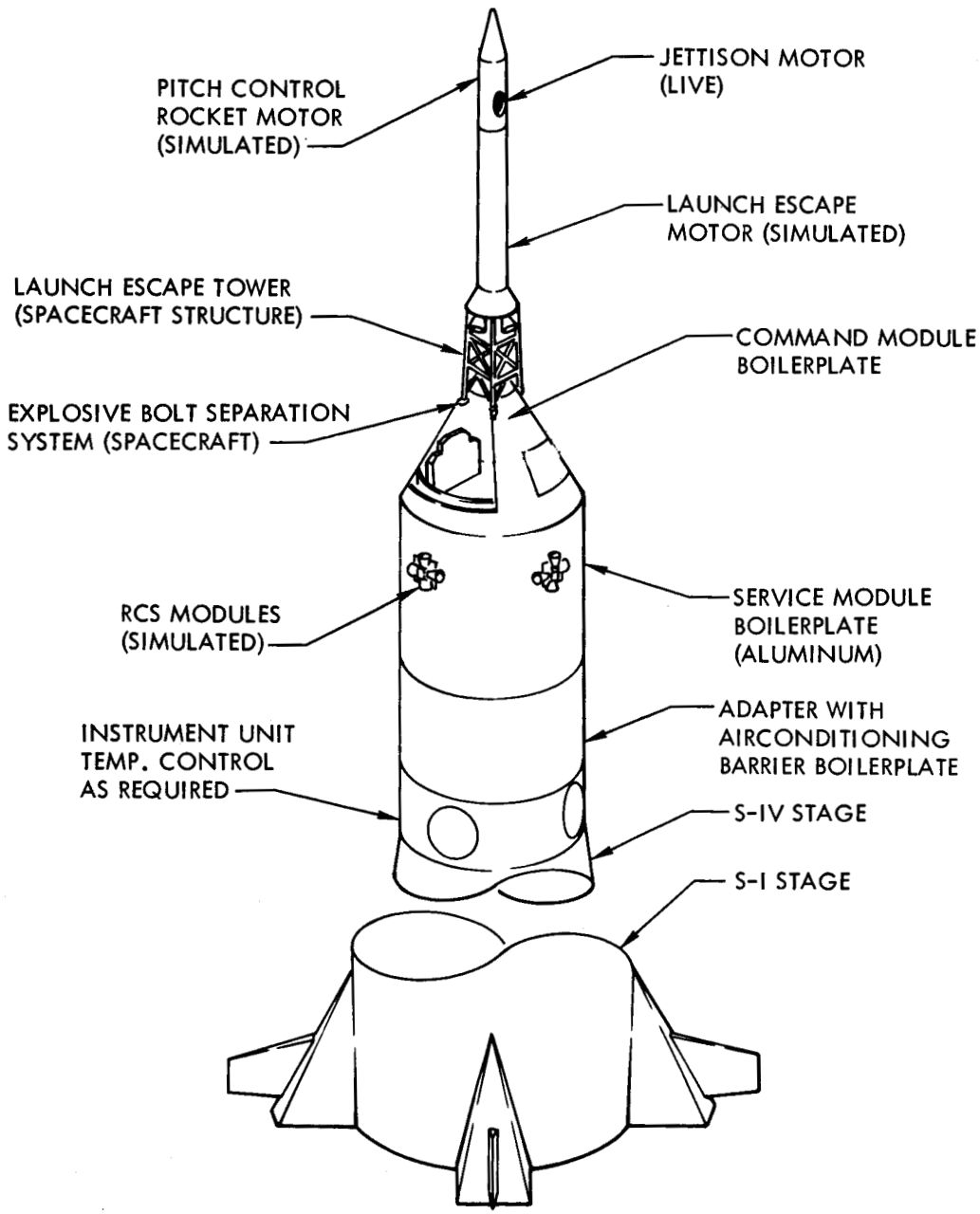

Figure 1. Boilerplate Number 16 Configuration

APPENDIX A

DRAWINGS

1. Scope. - The following list constitutes the top drawings of major components for Biolerplate Number 16.

Nomenclature	Number
General Assembly BP 16	B14-000002-231
General Assembly LES 12	B15-000002-171
Body Group Assembly	V15-300001-71
Tower Assembly	V15-300100-11
Tower Structure	V15-300102-241
Skirt Assembly	V15-300202-41
Power Supply Installation, Complete	B15-400001-71
Rocket Motor Set	B15-410001-41
Electrical Installation, Complete	B15-450016
Electrical Installation, Tower	B15-451401
Wiring Diagram	B15-450401
Electrical Installation, Motor	B15-451410
General Assembly, CM 22	B16-000002-281
Structure Assembly, Complete CM22	B16-300016
Structure Assembly	B16-301006-401
Structure, Aft Crew	B16-311006
Aft Bulkhead	B16-301081
Bulkhead-Forward Assembly	B16-301073-401
Structure-Aft Heat Shield	B16-327006-91
Cover Installation, Ablative	B16-320013
Electrical Installation, Complete	B16-450016
Electrical Installation, Crew Compartment	B16-451401
Wiring Diagram	B16-450430
Cover-Sequencer	B16-451207-11
Electrical Installation, Forward Compartment	B16-456401
Electrical Installation, Aft Compartment	B16-457401
General Assembly, SM5	B17-000002-191
Structure, Complete	B17-300016
Structure. Assembly	B17-320101
Structure Insert	B18-320113
Support Assembly	B17-320140-101

APPENDIX A (Continued)

DRAWINGS

Nomenclature	Number
Fairing Installation and Assembly	B17-320142
Fairing Assembly	B17-320141
Electrical Installation, Complete	B17-450016
General Assembly - Adapter 11	B18-000002-221
Structure, Complete	B18-300016

APPENDIX B

FLIGHT HARDWARE

1. Scope. - The flight hardware for Boilerplate Number 16 is to be determined by the MSFC.

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